

Section 3

Problem Formulation

The Problem Formulation phase of this ERA establishes the goals and describes the scope and focus of the assessment. In addition, this phase considers site-specific regulatory and policy issues and requirements and preliminarily identifies potential stressors (Section 3.1) and ecological resources potentially at risk (Section 3.2). The outcome of Problem Formulation is the site-specific conceptual exposure model (SCEM), which describes potential exposure pathways and the relationship between remedial action objectives, assessment endpoints, and measurement endpoints. Endpoints are defined and discussed in Section 3.3, and the site conceptual model is described in Section 3.4.

3.1 Stressor Identification

This ERA is focused on the potential ecological effects associated with PCB contamination of surface water, sediment, surface soil, and biota. Current levels of PCB contamination in these media can adversely affect aquatic and terrestrial ecosystems in and adjacent to the API/PC/KR. Other chemical stressors and physical (non-chemical) stressors, such as habitat disturbance, may also contribute to adverse ecological effects at this site. PCB contamination is considered to be the primary focus of this ERA because of the current magnitude and distribution of PCBs throughout the API/PC/KR (Figure 2-1, presented in Section 2). This ERA, therefore, does not consider the additional incremental effects that may be caused by other chemical stressors. Such effects are likely to be relatively minor compared to the actual or potential effects due to PCB exposures.

Dissolved and particulate-sorbed PCBs occur within and adjacent to the API/PC/KR boundaries. Based on extensive data for this site, the primary chemicals or groups of chemicals of potential concern for the API/PC/KR are PCBs. Of most concern are those with higher chlorine (Cl) content such as Aroclor 1016 (40 percent Cl by weight), 1242 (42 percent Cl), 1248 (48 percent Cl), 1254 (54 percent Cl), and 1260 (60 percent Cl). The more highly chlorinated PCBs are environmentally persistent and potentially most hazardous to ecological receptors (Eisler 1986). Most of the measured PCBs at the API/PC/KR are those that are persistent in the environment, such as Aroclors 1242, 1248, 1254, and 1260. Aroclor 1260 is the most commonly found Aroclor in biological tissue. This ERA is focused on the highly chlorinated PCBs observed in biotic and abiotic media.

It should be noted that from a regulatory perspective, all PCBs are regulated in Michigan as total PCBs, not as individual PCB congeners. Also, much of the toxicological literature on PCB effects is based on total PCB exposures. Total PCB concentrations, rather than Aroclor- or congener-specific PCB concentrations, are therefore used in this ERA to represent exposure concentrations. Evaluations of potential risk in this ERA are based on total PCB concentrations in abiotic media (e.g., surface water, sediment, surface soil) and biological tissues. Table 3-1 presents the

primary PCBs detected in abiotic and biological samples. The potential ecological effects associated with total PCBs are summarized in Section 4.2.1.

3.2 Ecological Resources Potentially at Risk

This section identifies and describes the major habitats and organisms, or types of organisms, that may be exposed to the chemical and physical stressors identified at the API/PC/KR site.

3.2.1 Habitat Descriptions

The API/PC/KR ERA is based on data collected from the Kalamazoo River upstream of the City of Battle Creek (upstream reference area) downstream to U.S. Highway 31, east of Lake Michigan (Figure 2-1). The area below Allegan Dam is considered to be impacted by current or past upstream PCB sources. The NPL (Superfund) site is the extent of Portage Creek and the Kalamazoo River including the 100-year floodplain prior to the removal of the Otsego, Plainwell, and Trowbridge Dams down to the sills. The major habitat types within the API/PC/KR site – aquatic habitats, riparian habitats/wetlands, and terrestrial habitats – are qualitatively described below.

Aquatic Habitats

Aquatic habitats within the API/PC/KR site are found within Portage Creek, the Kalamazoo River, and their tributaries. The Kalamazoo River is a large, perennial river that drains a major portion of western Michigan. The API/PC/KR site includes approximately 80 river miles. The character of the Kalamazoo River varies from reach to reach. The Kalamazoo River has been influenced by historic flood events as well as dam construction, operation, and removal. Currently, there are areas impacted by fluvially deposited sediments contaminated with anthropogenic chemicals within and adjacent to the river.

Instream substrates consist of variable proportions of the following:

- Boulders (>256 mm or 10 in)
- Cobble (64 to 256 mm or 2.5 to 10 in)
- Gravel (2 to 64 mm or 0.1 to 2.5 in)
- Sand (0.06 to 2.00 mm)
- Silt (0.004 to 0.06 mm)
- Clay (<0.004 mm)
- Organic matter (e.g., leaves, sticks, etc.)

A complete evaluation of particle size distribution of the API/PC/KR bed sediments has not been performed, but the following generalizations adequately describe the major types of API/PC/KR substrates and habitat conditions:

- Former impoundment sites and areas downstream of those subject to erosion are associated with increased siltation and decreased particle size, potentially increasing contaminant loads in these areas.

- Bottom substrates consist of unconsolidated materials, as well as some submerged and emergent vegetation, which may act as sediment traps.
- The relative abundance of potential fish cover (i.e., undercut banks, overhanging vegetation, deep pools, boulders, logs, aquatic vegetation) varies considerably within the API/PC/KR site. These areas are especially uncommon within certain sections of the broad floodplain where extensive sediment deposition has occurred.
- Stream channel stability varies with the pattern of annual flooding.
- Large areas associated with some of the former impoundments are commonly inundated for several months each year. These events result in seasonally increased habitat for receptors such as mink, muskrat, carp, amphibians, and crayfish.
- Areas of suitable habitat for abundant and diverse macroinvertebrate populations (i.e., cobble or gravel substrates with adequate water flow and depth) are uncommon and unevenly distributed throughout the API/PC/KR site.

To aid in the evaluation of aquatic habitats and chemical exposure for this ERA, the API/PC/KR site is divided into 12 Aquatic Biological Study Areas (ABSAs). Originally, ABSAs defined specific locations from which aquatic biota were collected. To describe aquatic habitats and potential exposure areas, these ABSAs were expanded so that they are contiguous, with ABSA boundaries based on physical features such as dam sites or bridges. This approach results in all reaches within the API/PC/KR site being associated with a specific ABSA. The expanded ABSAs and associated Terrestrial Biological Study Areas (TBSAs) are described in Table 3-2.

Terrestrial samples (e.g., white-footed/deer mice, earthworms, surface soil) were collected from specific areas within selected ABSAs. Soil sampling identified five acceptable terrestrial biological sampling areas (TBSAs 1, 3, 5, 10, and 11) from which terrestrial samples would be collected. In some cases, these soil and biota samples taken from the TBSAs can also be considered semi-aquatic rather than terrestrial because some of the sampling locations are commonly flooded for a significant portion of time each year. These "surface soil" samples collected within the floodplain are therefore not representative of terrestrial exposures in upland areas, and are probably best defined as floodplain sediments. Such sediments are more closely linked to aquatic rather than terrestrial environments from a source (deposition) perspective and from the types of biota inhabiting or utilizing these areas seasonally (e.g., spawning fish, amphibians, and crayfish in wet seasons and more terrestrial biota in dry seasons).

Each of the ABSAs and TBSAs correspond to particular areas of concern for this ERA. The major areas evaluated in this ERA include:

- Reference area (ABSA 1)

- The Portage Creek area (ABSA 12), which influences ABSA 3 and upstream portions of ABSA 4
- The former Plainwell Impoundment area, which influences the lower portion of ABSA 4 and all of ABSA 5
- The Otsego City Dam impoundment area (ABSA 6)
- The former Otsego Dam impoundment area (ABSA 7)
- The former Trowbridge Dam impoundment area (ABSA 8)
- Lake Allegan (ABSA 9)
- Areas immediately downstream of Lake Allegan that may be impacted by upstream areas (ABSA 10)

Impacts to each of these areas of concern are evaluated in this ERA on an ABSA-specific basis. In the Risk Characterization phase of the ERA, the ecological significance of ABSA-specific impacts to each of the major areas of concern is evaluated. Preliminary remedial goals (PRGs) are derived on a site-wide basis for different exposure scenarios and representative receptors.

Riparian Habitats/Wetlands

Riparian habitats exist adjacent to the watercourse of the Kalamazoo River and Portage Creek. Riparian habitats include both upland and wetland habitats within the floodplain of the river. Native floodplain soils are composed of fluvially deposited silts, fine to coarse sands, and gravels of varying sizes. In certain areas, these floodplain soils are covered with contaminated fine-grained sediments.

Numerous wetlands are identified within the API/PC/KR. These include shrub/scrub wetlands, emergent wetlands, and forested wetlands. These provide diverse and abundant vegetation and habitat for a wide variety of aquatic and riparian/terrestrial species dependent on aquatic ecosystems. These areas are, therefore, important for the health and status of several types of terrestrial as well as aquatic biota, and the types of biota supported by these wetlands may vary over season because of periodic flooding.

In general, the wetlands that occur throughout the API/PC/KR are dominated by a large variety of perennial grasses, shrubs, and trees common to western Michigan. See Appendix A for a detailed list of plant species. Outside of industrial or residential areas, there does not appear to be substantial differences in the diversity and abundance of riparian plants from one ABSA to another.

Terrestrial Habitats

Terrestrial habitats beyond the riparian areas and beyond the areas subject to seasonal inundation include relatively flat open areas with varying amounts of vegetative cover, some of which are used for grazing cattle. Also nearby are low rolling hills that are mostly thickly wooded and densely shaded. Terrestrial habitats in the API/PC/KR site are also found in portions of residential and industrial areas and represent ecological islands within urban areas. Finally, upland areas such as those identified in some cases as landfills are also considered terrestrial habitats.

3.2.2 Impacts to Ecological Resources

The API/PC/KR corridor supports a large variety of ecological resources (Section 3.2.3). This ERA is focused on addressing the impacts of PCB contamination to surface water, streambed sediments, floodplain sediments, and surficial soils, as well as biota that are adversely affected by ingestion of PCB-contaminated food items, resulting in increased levels of bioaccumulation of PCBs in higher trophic levels. Figures 3-1 through 3-10 show the results of observed PCB concentrations in various aquatic/semi-aquatic (surface water, fish, mink, muskrat, streambed sediments) and terrestrial (mice, earthworms, surface soils) media that were sampled in the defined ABSAs and TBSAs in accordance with the API/PC/KR Biota Sampling Plan (CDM 1993). Each figure provides the number of samples collected, and the mean, minimum, and maximum PCB concentrations observed in individual media for each ABSA or TBSA. Section 5, Risk Characterization, addresses the risks associated with the observed PCB contamination at the API/PC/KR site.

3.2.3 Identification of Potential Receptors

Potential ecological receptors for this study are defined as plants and animals (i.e., macroinvertebrates, fish, amphibians, reptiles, birds, and mammals) that inhabit or use, or have potential to inhabit or use, the aquatic, riparian/wetland, and terrestrial habitats of the API/PC/KR site. Although other organisms such as bacteria, protozoans, and fungi are essential components of aquatic and terrestrial ecosystems, potential impacts to these organisms are not assessed in this ERA because adequate data are unavailable for such an assessment.

Field surveys conducted by CDM and others revealed a large variety of plant and animal species utilizing all available habitat types in the study area. Studies were not conducted specifically to evaluate relative abundance or diversity of plant and animal species resident to or using the API/PC/KR. In general, however, a large variety of plant and animal species expected in the area were observed during fieldwork conducted in support of the ERA (See Appendix A).

Several plant and animal species of special concern have potential to exist in the study area (Appendix A), including threatened, endangered, and sensitive species such as white false indigo, bald eagle, great blue heron, eastern box turtle, marbled salamander, black redhorse, lake sturgeon, frosted elfin, red-shouldered hawk, and

elktoe mussel. Bald eagles do nest within the lower reaches of the API/PC/KR site, and great blue herons have an established heron rookery along the Kalamazoo River downstream of Lake Allegan. Appendix A also provides lists of invertebrates, fish, amphibians, reptiles, birds, and mammals that are found in this part of Michigan. All of these species have potential to occur within the API/PC/KR site.

Major species, including local subspecies, or types of organisms that have been observed onsite, expected to inhabit or use the API/PC/KR environs, or have potential to inhabit or use the area are described below. The species lists, presented in Appendix A, do not identify every plant or invertebrate that occurs or might occur onsite, but instead include observed species and representatives of major groups of these organisms that may occur onsite. Vertebrate species, including subspecies if applicable, that (1) have been observed onsite, (2) are likely to occur onsite, or (3) have potential to occur onsite, are considered potential receptors and are therefore included in the species lists provided. The potential to inhabit or use the API/PC/KR is based on published geographical ranges, general habitat requirements, comparison to nearby reference areas and, in some cases, the remediation of critical chemical or physical stressors.

The large number of potential receptor species identified for the API/PC/KR obviously precludes an assessment of potential risks for every species listed. Several species or groups of organisms have therefore been selected to serve as representative receptors for a detailed evaluation of potential risks. The selection of these receptors is based on

- (1) their perceived importance to local ecosystems (e.g., key prey species),
- (2) their population status,
- (3) their relationship with human use (e.g., game species),
- (4) the size of their home range in relation to the area,
- (5) sensitivity to PCBs, and
- (6) the availability of data for assessing potential risk.

Using these criteria, the following nine groups of organisms are selected as final ecological receptors for the API/PC/KR.

Aquatic Plants

Primary producers in aquatic ecosystems; can be important food items for zooplankton and other invertebrates which, in turn, are preyed upon by small/young fish and other aquatic life; potentially abundant; potential for high biomass (e.g., algae).

Aquatic and Semi-Aquatic Macroinvertebrates

Important prey species for many game fish; potentially abundant; potential for high biomass (e.g., larval midges, mayflies, stoneflies, caddisflies, and amphipods). Semi-aquatic invertebrates such as crayfish may be important food items for mink and other predators.

Freshwater Game Fish

Potential for high biomass; significant relationship with human use (e.g., smallmouth bass and salmonids).

Freshwater Forage Fish

Potential for high biomass; likely to be significant prey item for piscivorous predators, including game fish (e.g., white sucker).

Freshwater Rough Fish

Potential for high biomass; likely to be significant prey item for piscivorous predators, including mink; intimate contact with potentially contaminated sediment (e.g., common carp).

Terrestrial Invertebrates

Abundant; important prey species for shrews, birds, toads, etc. (e.g., earthworms).

Small Burrowing Terrestrial and Semi-Aquatic Mammals

Abundant; important prey species for certain snakes, birds, and mammals; significant relationship with humans (e.g., white-footed or deer mouse and muskrat).

Small Carnivorous/Omnivorous Mammals

Relatively abundant; relatively small home range; important consumers of aquatic and terrestrial biota; sensitive to PCB exposure; significant relationship with humans (e.g., mink).

Top Predators

At greatest risk for contaminants that bioaccumulate and biomagnify, including PCBs; significant relationship with humans; potentially species of concern (e.g., red fox, great horned owl, peregrine falcon, bald eagle).

3.3 Identification of Endpoints

This section introduces, defines, and discusses appropriate assessment and measurement endpoints for evaluating potential ecological effects.

3.3.1 Assessment Endpoints

Assessment endpoints identify the ecological values to be protected (e.g., abundance and diversity of aquatic macroinvertebrates or fish). Assessment endpoints are directly related to ERA-related remedial action goals and objectives determined for the API/PC/KR site. Appropriate assessment endpoints are developed by risk

assessors and often consider guidance from relevant regulatory agencies. ERA-related remedial action goals and objectives for the API/PC/KR have been determined by MDEQ, and include:

1. The establishment and maintenance of a healthy and diverse aquatic ecosystem in and adjacent to the API/PC/KR site
2. Reductions in PCB concentrations in fish and wildlife such that human consumption restrictions can be lifted

Site-specific remedial action goals and objectives should include:

1. The removal from the environment and isolation of all PCB-contaminated soils, sediments, and groundwater to a level that will achieve state water quality standards in the Kalamazoo River and Portage Creek (0.000026 µg/L for human health and 0.00012 µg/L for wildlife)
2. Remediation until residual levels in the environment are so low that healthy, safe-to-consume (e.g. no fish fillets greater than 2 ppm), self-reproducing, and ecologically diverse fish and wildlife populations can return to and survive in the Kalamazoo River basin

The Michigan Department of Environmental Quality suggests that water, soil, and whole fish cleanup objectives be set at current minimum detectable levels of 0.33 ppm. These are to be achieved while avoiding or minimizing a loss of floodway/floodplain capacity, reductions in river channel length, or loss of wetland values. Assessment endpoints are described as explicit expressions of the environmental variable(s) that are to be protected. The characteristics of the contaminants of concern, toxic mechanisms, and exposure pathways were used to select the following assessment endpoints:

- Preservation of the fish populations (e.g., smallmouth bass and white sucker) and communities utilizing the Kalamazoo River and Portage Creek system
- Preservation of the survival, growth, and reproductive capacity of aquatic receptors (e.g., aquatic plants, benthic macroinvertebrates, fish, larval amphibians) utilizing the Kalamazoo River and Portage Creek system
- Preservation of the survival, growth, and reproductive capacity of mammalian receptors (e.g., mouse, mink, muskrat, red fox) utilizing the Kalamazoo River and Portage Creek system
- Preservation of the survival, growth, and reproductive capacity of avian receptors (e.g., robin, bald eagle, and great-horned owl) utilizing the Kalamazoo River and Portage Creek system

It is assumed that the protection of the aforementioned sensitive aquatic and terrestrial receptors would be associated with the protection of other sensitive organisms or receptors for which toxicity data are lacking such as reptiles, songbirds, etc.

3.3.2 Measurement Endpoints

Assessment endpoints are often difficult to measure or evaluate directly. For example, we cannot predict with certainty the critical concentration of PCBs in surface water and sediment that allows survival and successful reproduction of smallmouth bass or salmonids in the Kalamazoo River. Such critical concentrations are site-specific and depend on innumerable factors. These factors may include the water quality and dietary requirements of prey species consumed by game fish, chemical interactions (i.e., synergistic, antagonistic, or additive), and the physical and chemical characteristics of the API/PC/KR site (e.g., streambed particle size, sediment organic carbon content, dissolved organic carbon concentration in surface water, temperature, dissolved oxygen, streambank and in-stream cover, etc.).

Measurement endpoints are used in cases where assessment endpoints cannot be directly measured or evaluated. Measurement endpoints are *quantitative expressions of observed or measured biological responses to stressors relevant to selected assessment endpoints*. For example, macroinvertebrate abundance (an assessment endpoint) can be evaluated using aquatic toxicity data based on an appropriate measurement endpoint. For example, concentrations of PCBs in API/PC/KR surface water can be compared to concentrations in laboratory test water that resulted in observed ecologically significant effects to sensitive and relevant test species (e.g., smallmouth bass or closely related species).

For this ERA, ecologically significant effects are defined as those affecting survival, growth, or reproduction. Other ecologically significant impacts such as effects on metabolic health were not considered. The example described above expresses the relationship between a relevant measurement endpoint (chronic effects concentration of PCBs in surface water) that is directly related to the assessment endpoints of game fish abundance and reproduction. Measurement endpoints selected for this are based on information from appropriate aquatic ecology/toxicology studies, water quality studies, and terrestrial toxicological studies (e.g., data summarized in EPA 1980 and Eisler 1986) and on site-specific abiotic and biological data.

3.4 Site Conceptual Exposure Model

The site conceptual exposure model (SCEM) is the primary output of the Problem Formulation phase of the ERA, and is used to develop a series of testable null hypotheses for the API/PC/KR, primarily those regarding potential exposure scenarios and the relationship between selected assessment and measurement endpoints. The null hypotheses for the API/PC/KR are defined as follows:

- The levels of PCBs in water, sediment, and biota are not sufficient to adversely affect the structure or function of the fish populations in the Kalamazoo River and Portage Creek System
- The levels of PCBs in water, sediment, and biota are not sufficient to adversely affect the survival, growth, and reproduction of aquatic plant and animal receptors utilizing the Kalamazoo River and Portage Creek system
- The levels of PCBs in water, sediment, and biota are not sufficient to adversely affect the survival, growth, and reproduction of semi-aquatic and terrestrial mammalian receptors utilizing the Kalamazoo River and Portage Creek system
- The levels of PCBs in water, sediment, and biota are not sufficient to adversely affect the survival, growth, and reproduction of omnivorous and carnivorous avian receptors utilizing the Kalamazoo River and Portage Creek system

The term “sediment” as used in the aforementioned hypotheses refers to both instream and floodplain sediments. The latter can also be termed “floodplain soils”, with the recognition that these apparently terrestrial areas are frequently inundated for long durations (in some cases over half the year).

The conceptual model (Figure 3-11) presents the potential exposure pathways for the primary chemical stressors (PCBs) associated with past industrial activities in or near the API/PC/KR site. These pathways indicate how the ecological resources can co-occur or come in contact with hazardous chemicals or materials such as PCB-contaminated sediments, and include contaminant sources, fate, and transport processes, and exposure routes. Some of the pathways shown in Figure 3-11 are considered to be relatively minor, and not all are fully evaluated in this ERA.

This ERA is focused primarily on assessing population-level risks associated with PCB contamination in abiotic media and biota. Because of the potential for PCBs to accumulate in biological tissues and exert adverse effects in upper trophic level biota, this ERA specifically considers bioaccumulation, food chain effects, and adverse effects in upper trophic level organisms. Reproductive effects in upper trophic level organisms, such as top predators, commonly follow long-term PCB exposure. Since reproductive effects are often observed before other types of effects, protection against reproductive effects should ensure that other adverse effects would not occur. Therefore, reproductive endpoints for top predators are also considered critical to this ERA. Finally, it is assumed in this ERA that population-level effects are most important for most species and that the loss of a single individual is not critical to the population or community. The focus on population-level effects rather than on effects to individual organisms is modified in this ERA for threatened or endangered species. In this case, adverse effects or a loss of even one individual is considered important. Related to the conceptual model are the preliminarily identified remedial action objectives for the API/PC/KR presented in Section 3.3.1. Table 3-3 summarizes the

relationship between assessment endpoints, hypotheses, measurement endpoints, and receptors.

3.5 Uncertainties – Problem Formulation

Uncertainties in Problem Formulation can arise from several sources, most significantly from assumptions used to initially focus the ERA. This ERA is by regulatory direction focused on the primary chemical contaminants identified at this site – PCBs. It is recognized that other chemical stressors have been identified onsite, including some that can be highly toxic and are known to substantially bioaccumulate. It is also recognized that this focused ERA is specifically intended to address PCB contamination at this site.

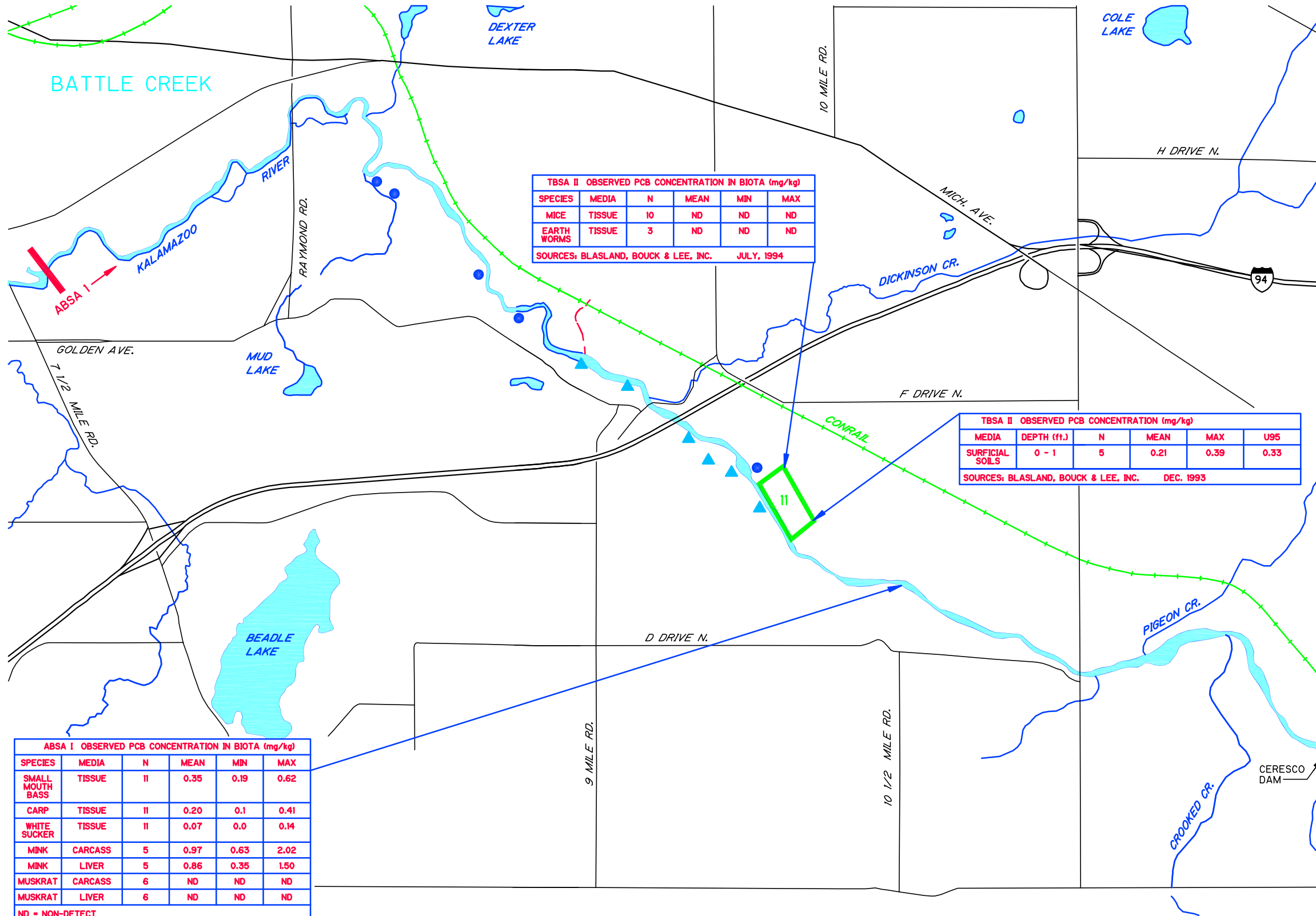
The major uncertainties in the Problem Formulation phase of the ERA probably stem from the assumptions used to develop the SCEM. The SCEM developed for this ERA is based on a focused ERA in which only key exposure pathways and chemical stressors are fully evaluated. Therefore, uncertainties associated with other minor exposure pathways (e.g., inhalation), or chemical stressors other than PCBs, will not affect the outcome of this focused ERA. All major exposure pathways and pathway components related to PCB contamination at this site have been included in the SCEM. No sources of uncertainty are identified at this stage of the ERA that will substantially affect the outcome of the ERA.

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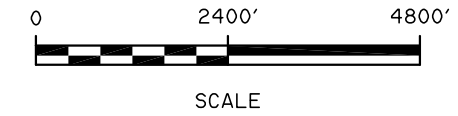
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- TBSA II SAMPLING LOCATION
- ABSA I MUSKRAT CAPTURE LOCATION
- ABSA I MINK CAPTURE LOCATION
- ABSA BOUNDARY

- NOTE:
- PLANIMETRIC MAPPING OBTAINED FROM MICHIGAN RESOURCE INFORMATION SYSTEMS.
 - BASE MAP ADAPTED FROM BLASLAND, BOUCK & LEE, INC. (JULY 1994)
 - SURFACE CONCENTRATION FOR ABSA1 IS THE SAME AS ABSA2 WHICH WAS COLLECTED FROM 35th AVENUE



ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE
KALAMAZOO RIVER ECOLOGICAL RISK ASSESSMENT
OBSERVED PCB CONCENTRATIONS IN AQUATIC & TERRESTRIAL MEDIA
UPSTREAM REFERENCE AREA NEAR BATTLE CREEK

ABSA 1

Figure No. 3 - 1

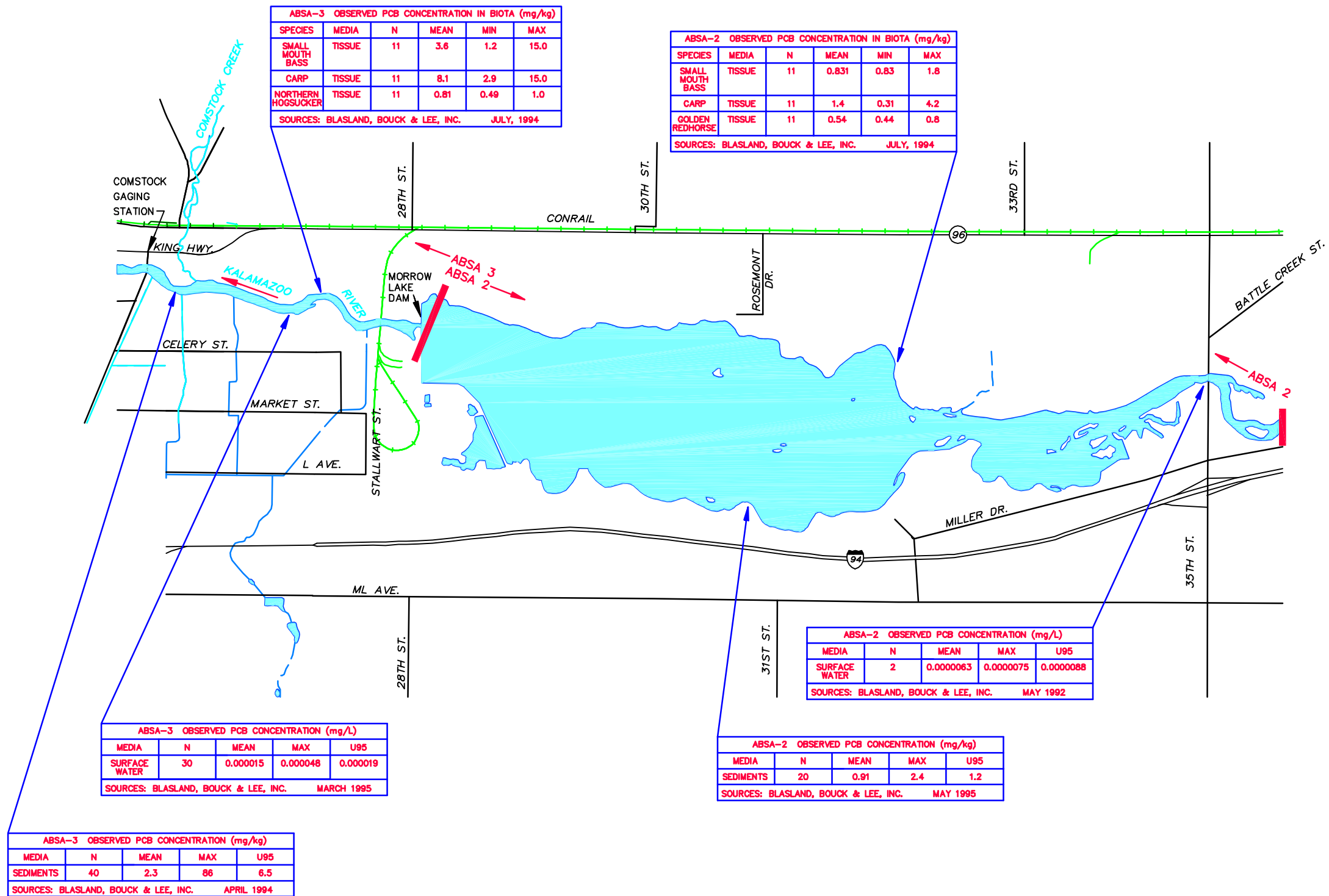
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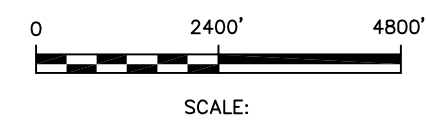


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ABSA BOUNDARIES

NOTE:

1. PLANIMETRIC MAPPING OBTAINED FROM MICHIGAN RESOURCE INFORMATION SYSTEMS.
2. SAMPLING AREAS APPROXIMATED BY BLASLAND, BOUCK & LEE, INC.
3. BASE MAP ADAPTED FROM BLASLAND, BOUCK & LEE, INC. (JULY 1994)



ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE
KALAMAZOO RIVER ECOLOGICAL RISK ASSESSMENT
OBSERVED PCB CONCENTRATIONS IN AQUATIC MEDIA
MORROW LAKE AREA

ABSA 2
ABSA 3
Figure No. 3 - 2

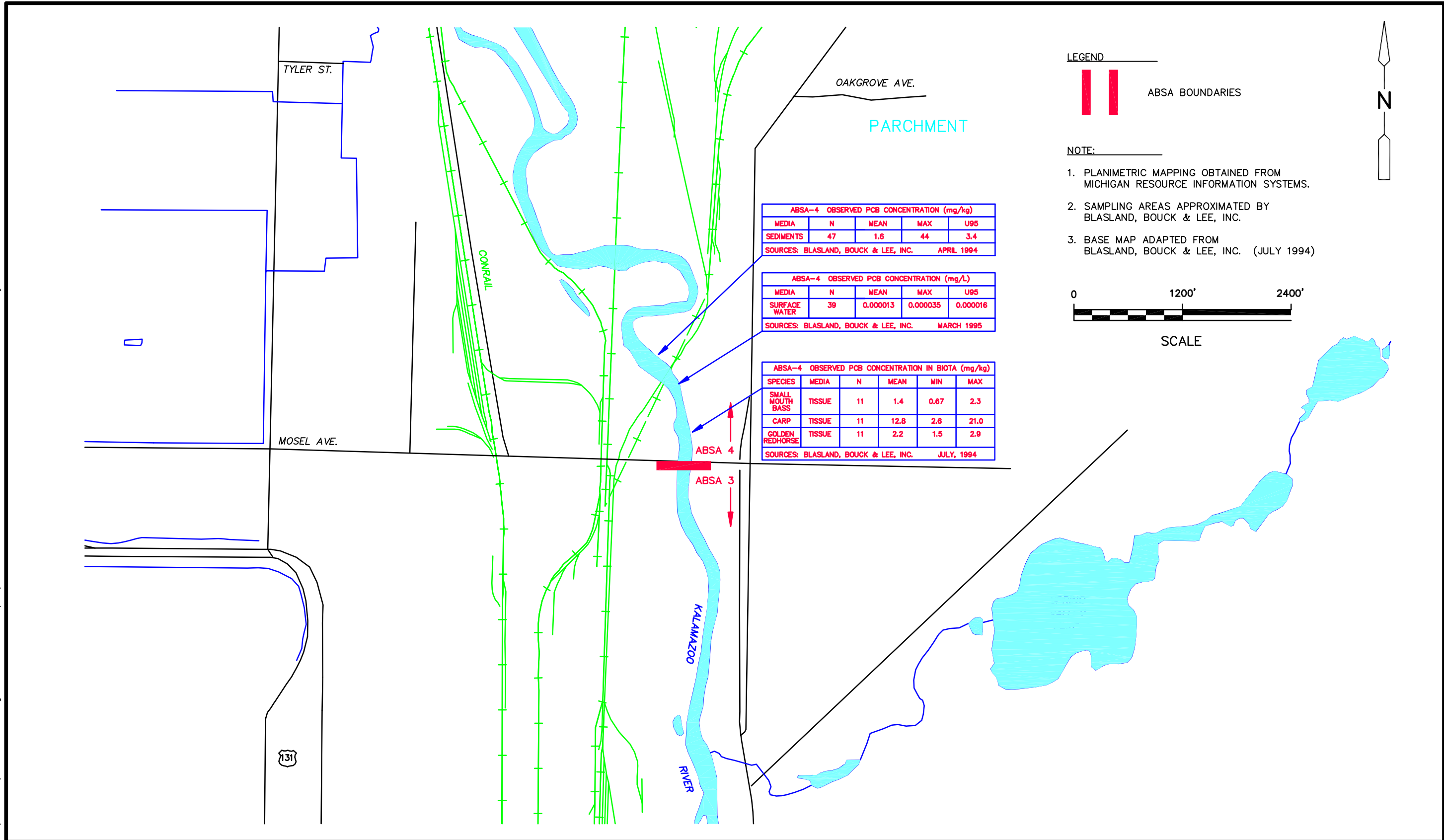
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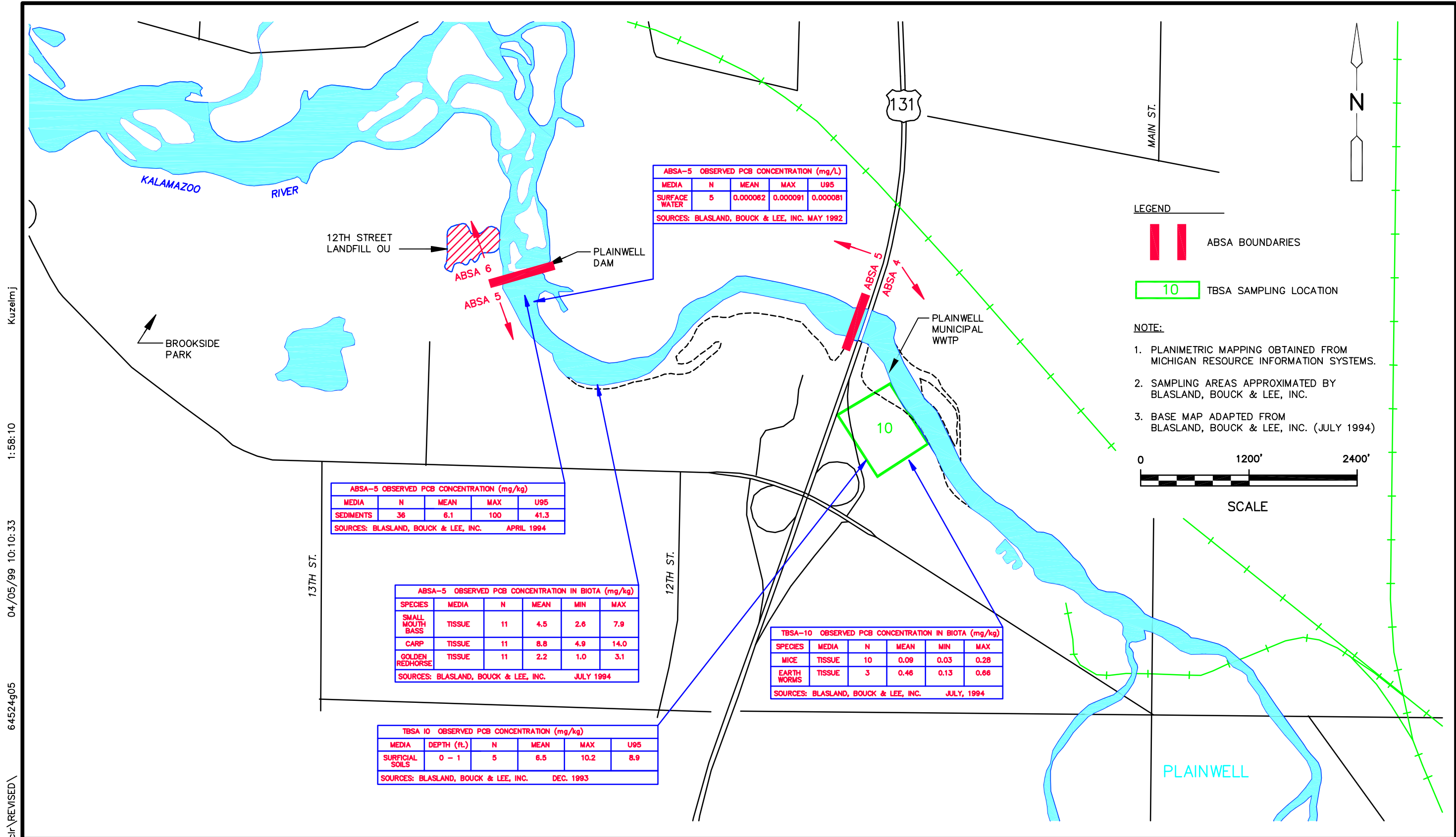
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OBSERVED PCB CONCENTRATIONS IN AQUATIC MEDIA
MOSEL AVENUE AREA



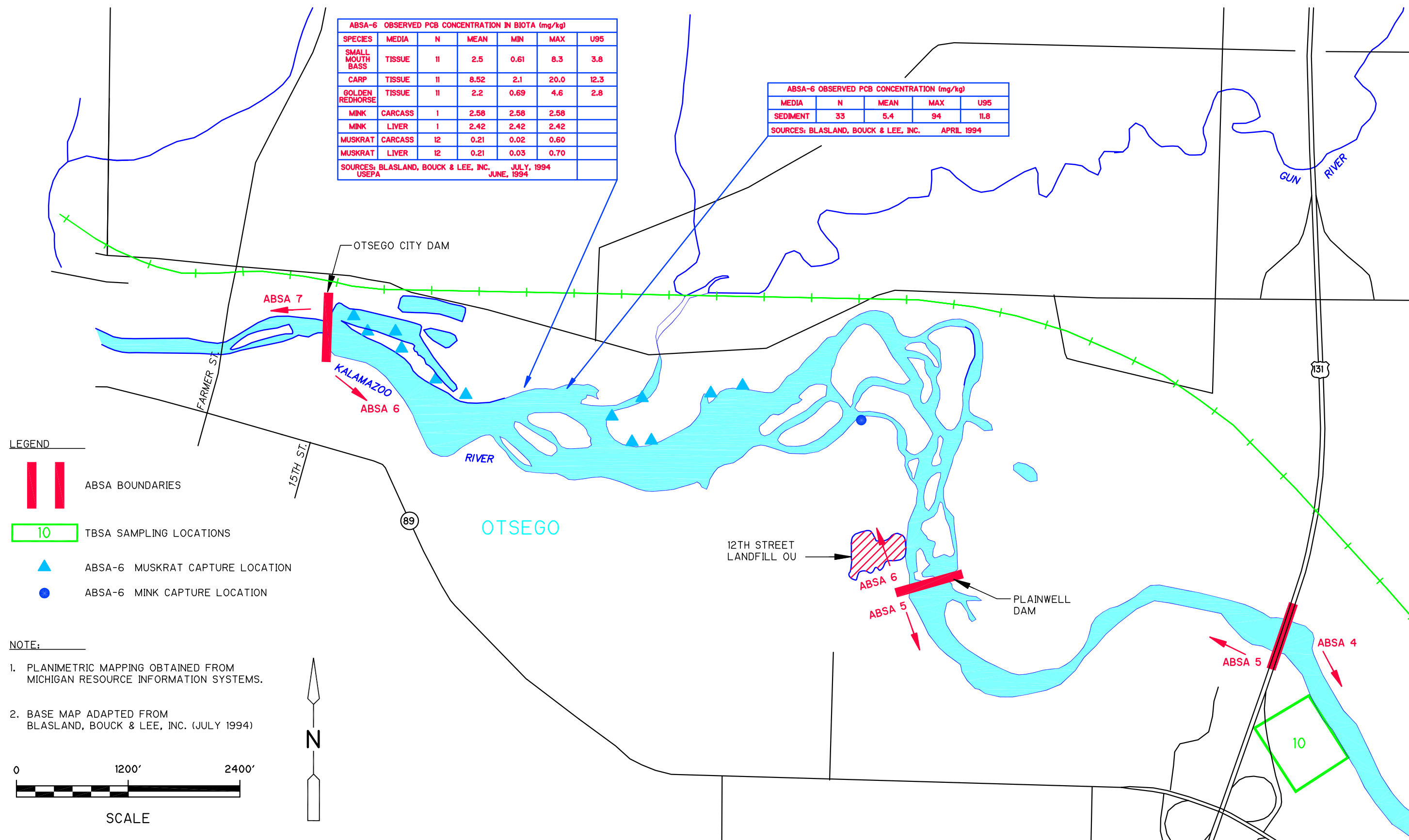
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KALAMAZOO RIVER ECOLOGICAL RISK ASSESSMENT
OBSERVED PCB CONCENTRATIONS IN AQUATIC AND TERRESTRIAL MEDIA
UPSTREAM OF PLAINWELL DAM

ABSA 4
ABSA 5

Figure No. 3 - 4

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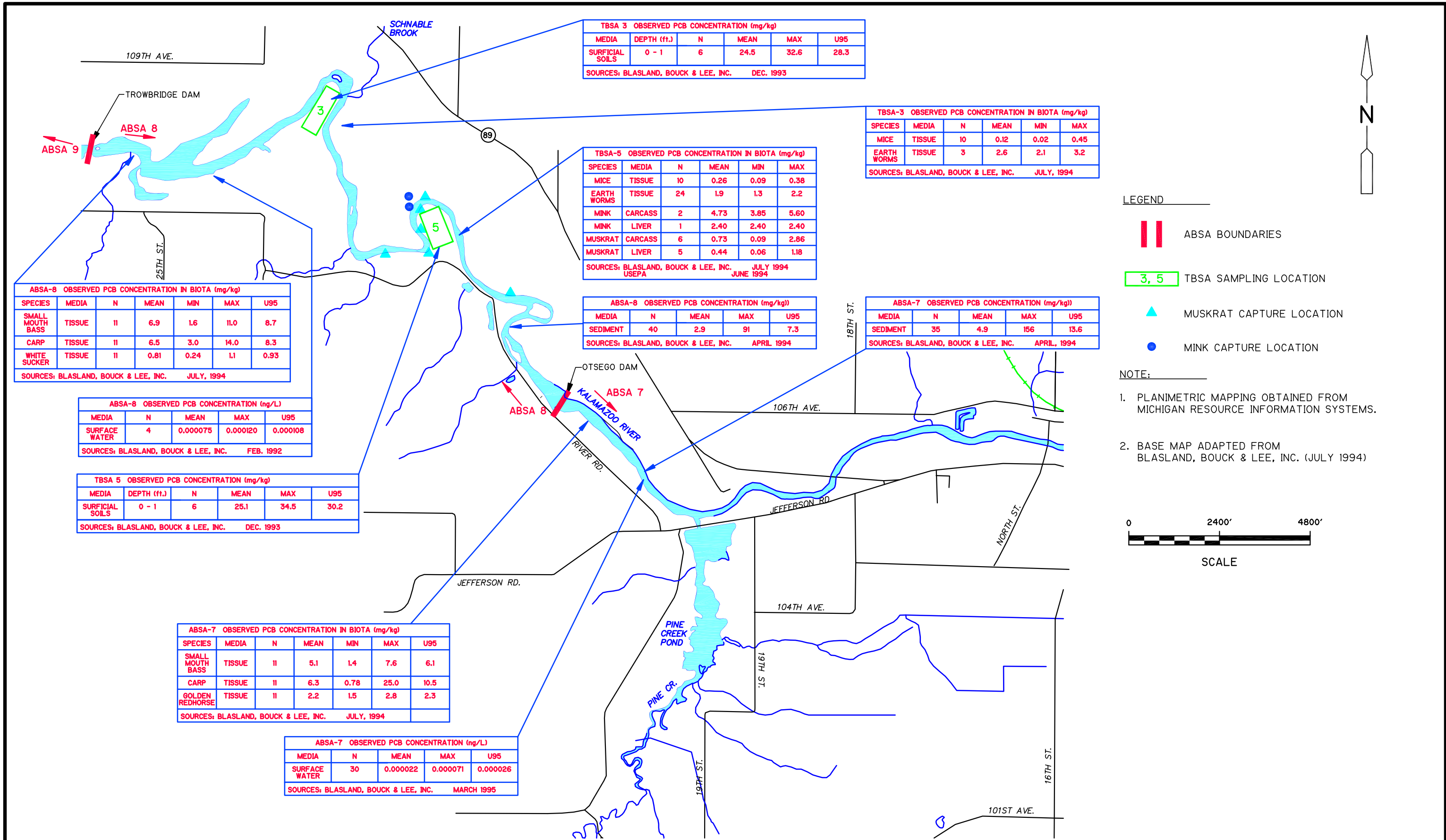
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KALAMAZOO RIVER ECOLOGICAL RISK ASSESSMENT
OBSERVED PCB CONCENTRATIONS IN AQUATIC & TERRESTRIAL MEDIA
BETWEEN OF OTSEGO CITY DAM AND PLAINWELL DAM

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ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

KALAMAZOO RIVER ECOLOGICAL RISK ASSESSMENT
OBSERVED PCB CONCENTRATIONS IN AQUATIC & TERRESTRIAL MEDIA
TROWBRIDGE DAM AREA UPSTREAM TO OTSEGO

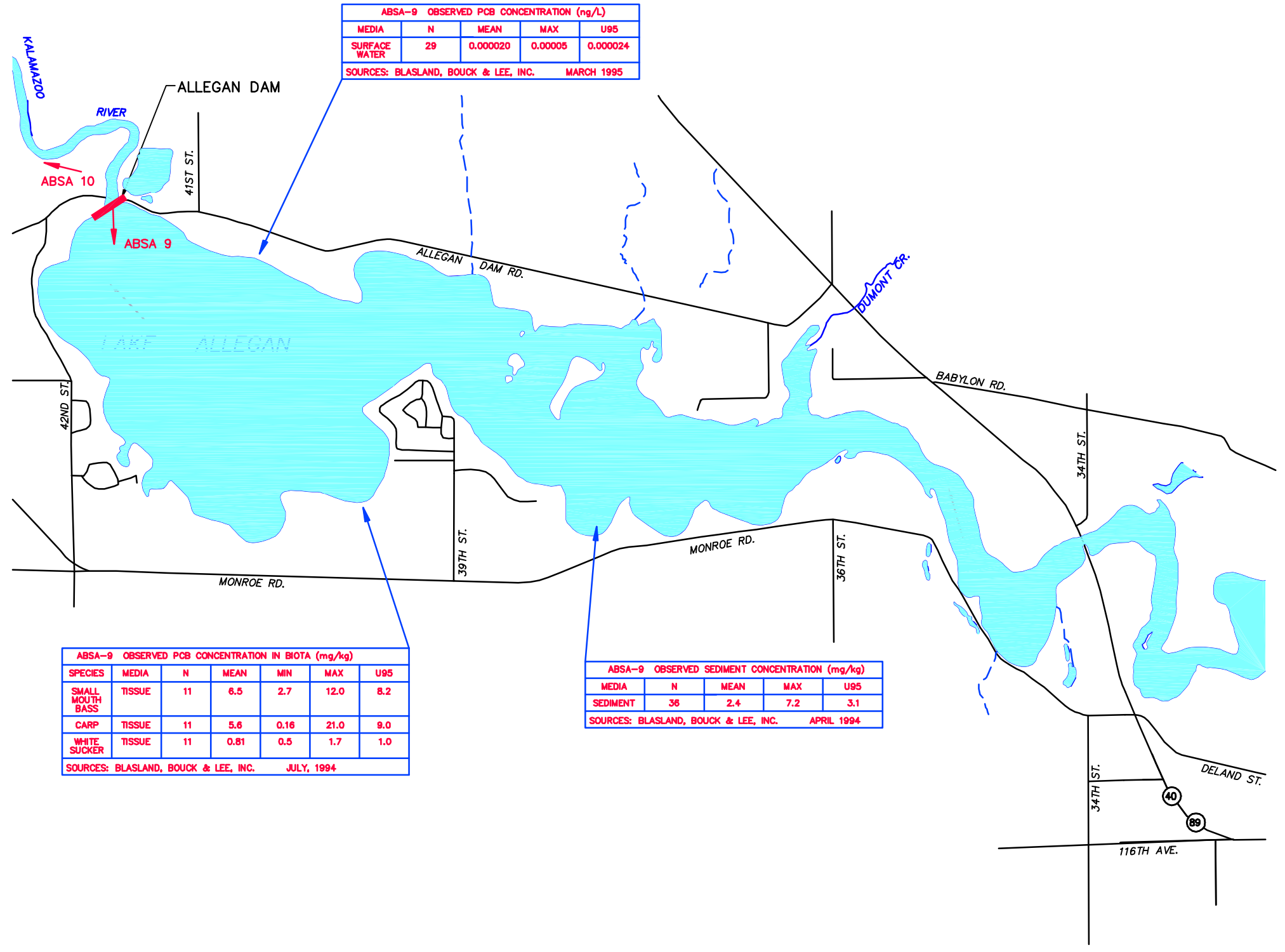
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ABSA-9 OBSERVED PCB CONCENTRATION (ng/L)				
MEDIA	N	MEAN	MAX	U95
SURFACE WATER	29	0.000020	0.00005	0.000024
SOURCES: BLASLAND, BOUCK & LEE, INC. MARCH 1995				

ABSA-9 OBSERVED PCB CONCENTRATION IN BIOTA (mg/kg)						
SPECIES	MEDIA	N	MEAN	MIN	MAX	U95
SMALL MOUTH BASS	TISSUE	11	6.5	2.7	12.0	8.2
CARP	TISSUE	11	5.6	0.16	21.0	9.0
WHITE SUCKER	TISSUE	11	0.81	0.5	1.7	1.0
SOURCES: BLASLAND, BOUCK & LEE, INC. JULY, 1994						

ABSA-9 OBSERVED SEDIMENT CONCENTRATION (mg/kg)				
MEDIA	N	MEAN	MAX	U95
SEDIMENT	36	2.4	7.2	3.1
SOURCES: BLASLAND, BOUCK & LEE, INC. APRIL 1994				



LEGEND

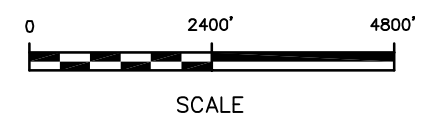
|| ABSA BOUNDARIES

NOTE:

1. PLANIMETRIC MAPPING OBTAINED FROM MICHIGAN RESOURCE INFORMATION SYSTEMS.

2. SAMPLING AREAS APPROXIMATED BY BLASLAND, BOUCK & LEE, INC.

3. BASE MAP ADAPTED FROM BLASLAND, BOUCK & LEE, INC. (JULY 1994)



ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

KALAMAZOO RIVER ECOLOGICAL RISK ASSESSMENT

OBSERVED PCB CONCENTRATIONS IN AQUATIC MEDIA

LAKE ALLEGAN

CDM
environmental engineers, scientists,
planners, & management consultants

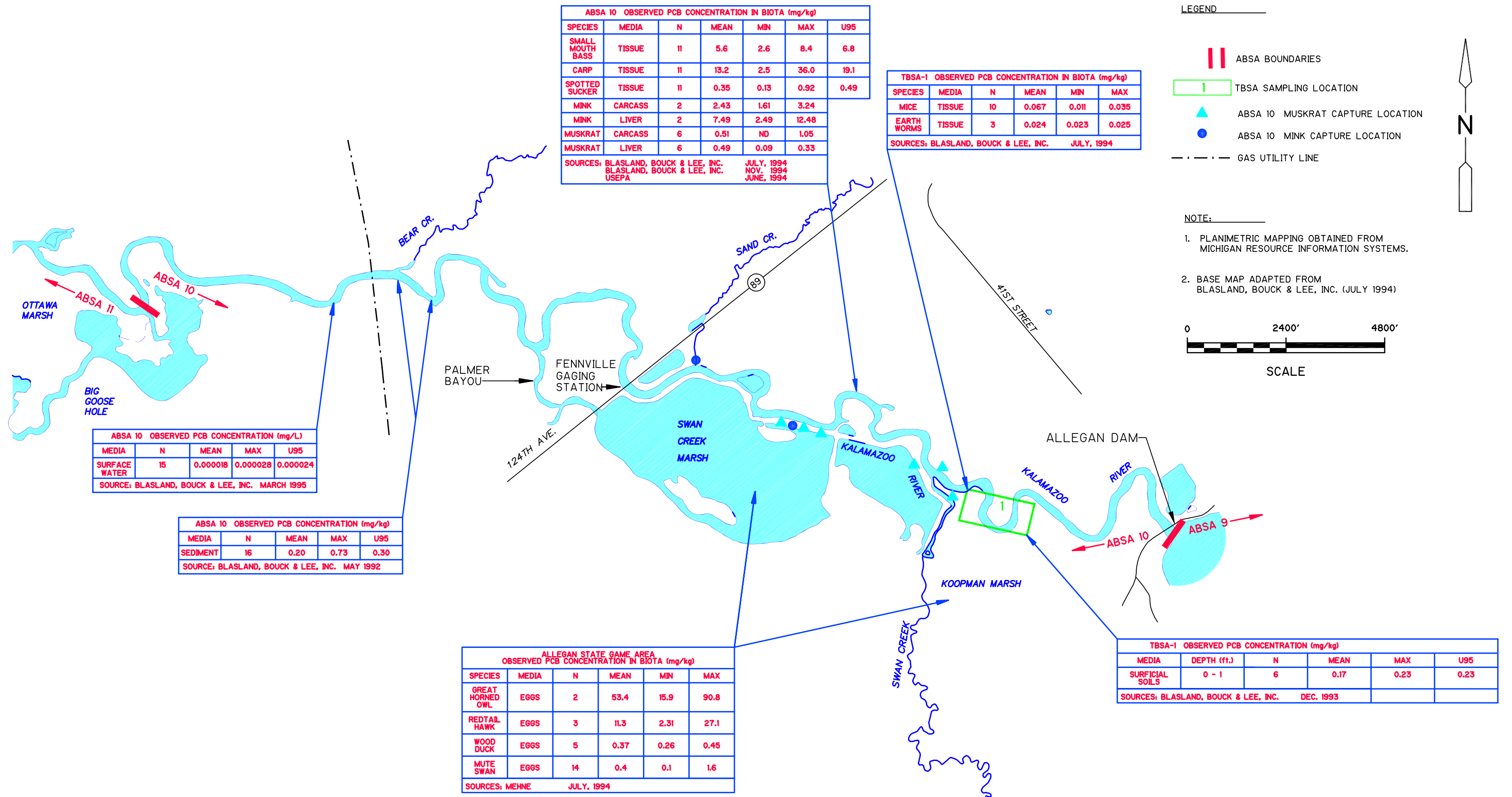
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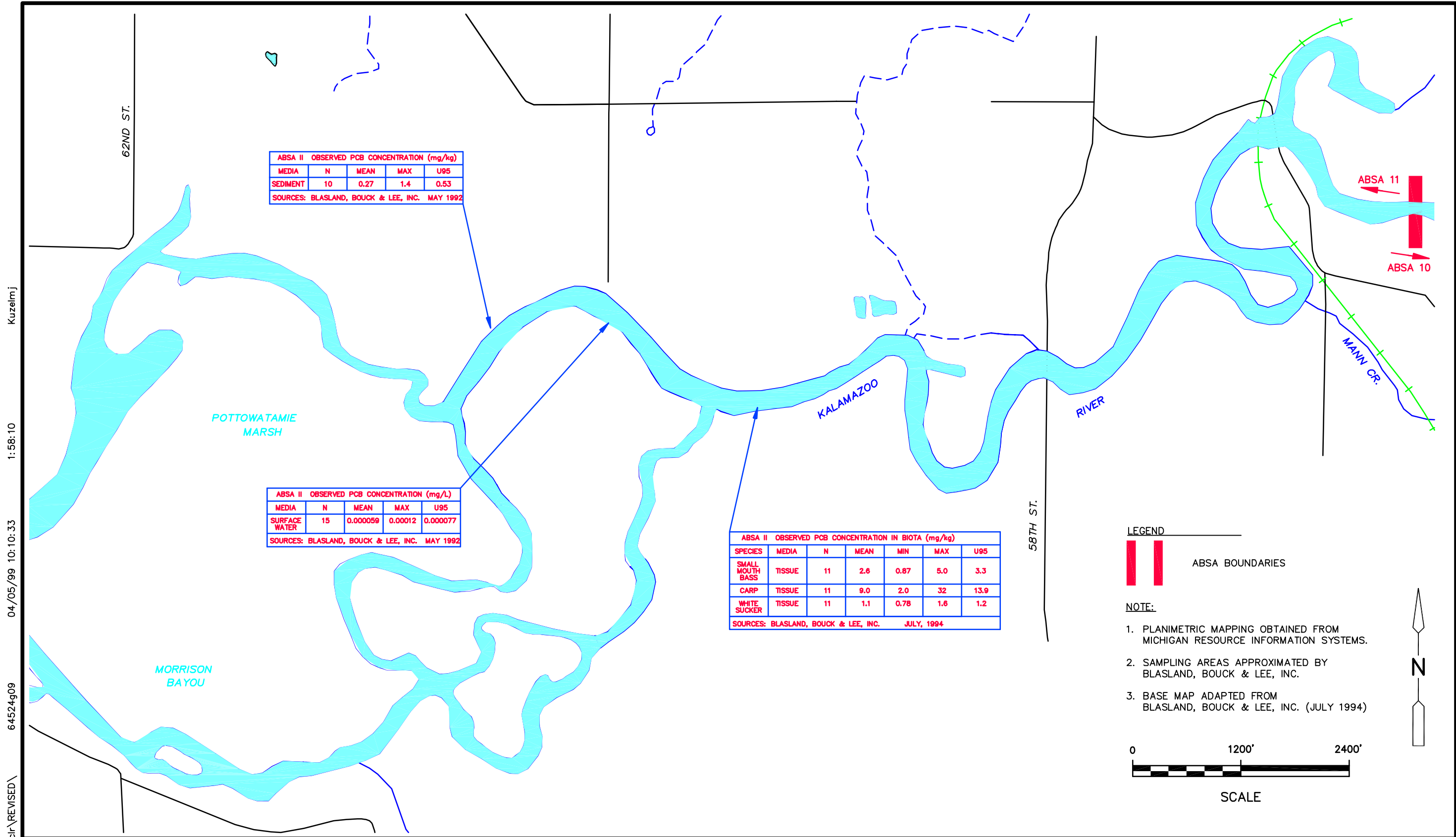
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ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE
KALAMAZOO RIVER ECOLOGICAL RISK ASSESSMENT
OBSERVED PCB CONCENTRATIONS IN AQUATIC AND TERRESTRIAL MEDIA
DOWNSTREAM OF ALLEGAN DAM





ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

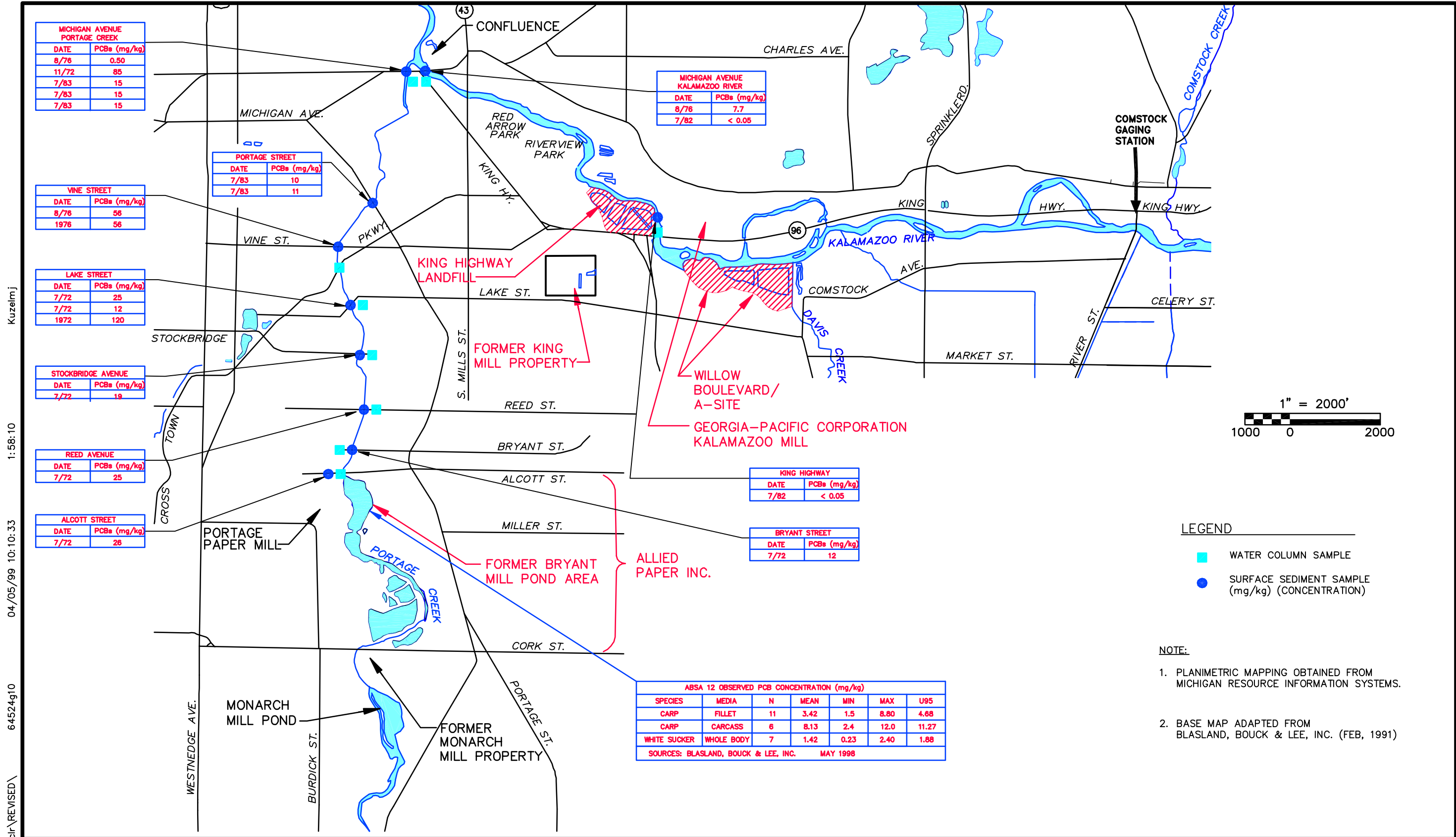
KALAMAZOO RIVER ECOLOGICAL RISK ASSESSMENT

OBSERVED PCB CONCENTRATIONS IN AQUATIC MEDIA

POTTOWATAMIE MARSH AREA

ABSA 11

Figure No. 3 - 9



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**FIGURE 3-11
POTENTIAL EXPOSURE SCENARIOS
SITE CONCEPTUAL MODEL
API/PC/KR**

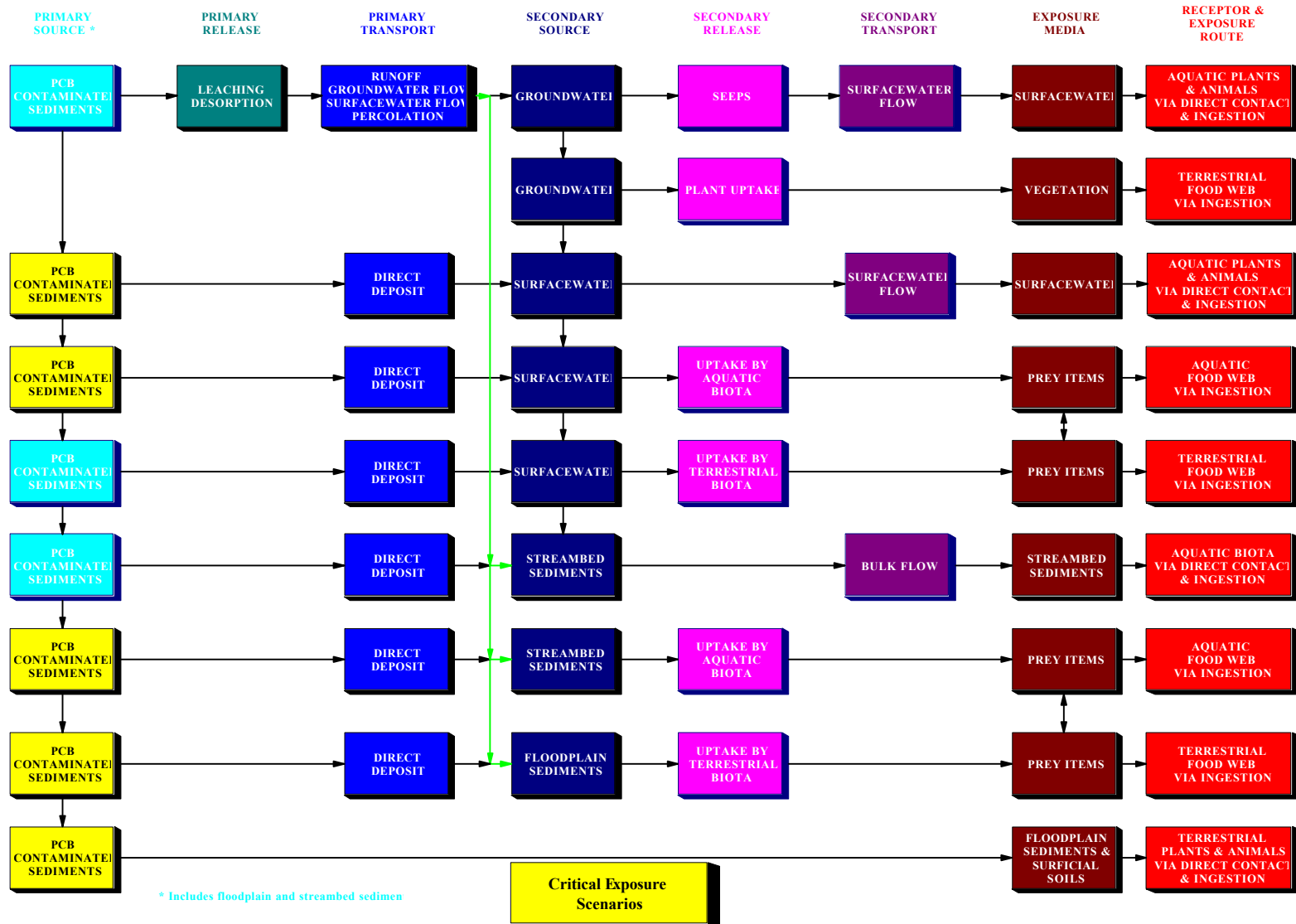


Table 3-1

Polychlorinated Biphenyls (PCBs) Detected in Abiotic and Biological Samples

API/PC/KR

PCBs	Media of Concern
Aroclor 1260	SW, SED, FP SED, SS, BIO
Aroclor 1254	SW, SED, FP SED, SS, BIO
Aroclor 1248	SW, SED, FP SED, SS, BIO
Aroclor 1242	SW, SED, FP SED, SS, BIO
Aroclor 1232	SW, SED, FP SED, SS
Aroclor 1221	SW, SED, FP SED, SS
Aroclor 1016	SW, SED, FP SED, SS, BIO

SW	Surface Water
SED	Streambed Sediment
FP SED/SS	Floodplain Sediment/Surface Soil (sediments deposited within 100-year floodplain)
SS	Surface Soil (from soil samples taken from terrestrial biological study areas (TBSAs))
BIO	Biological tissue

Table 3-2
Biological Study Areas
API/PC/KR

ABSA 1	Kalamazoo River upstream of the city of Battle Creek (upstream reference site). Aquatic biota were collected near the I-94 junction with the Kalamazoo River. Includes TBSA 11. (See Figure 3-1).
ABSA 2	Kalamazoo River from the downstream boundary of ABSA 1 to Morrow Lake Dam. Aquatic biota were collected from Morrow Lake. (See Figure 3-2).
ABSA 3	Kalamazoo River from Morrow Dam to Mosel Ave., Kalamazoo. Aquatic biota were collected just downstream of Morrow Dam. (See Figure 3-2).
ABSA 4	Kalamazoo River at Mosel Ave. to Hwy. 131 bridge. Aquatic biota were collected from the Kalamazoo River near Mosel Avenue. (See Figure 3-3).
ABSA 5	Kalamazoo River near Hwy 131 bridge and Plainwell Dam. Aquatic biota were collected from the Kalamazoo River upstream of Plainwell Dam. Includes TBSAs 8, 9 and 10. (See Figures 3-4).
ABSA 6	Kalamazoo River from Plainwell Dam to Otsego City Dam. Aquatic biota were collected from the Kalamazoo River upstream of Otsego City Dam. Includes TBSA 10. (See Figures 3-5).
ABSA 7	Kalamazoo River from Otsego City Dam to Otsego Dam. Aquatic biota were collected just upstream of Otsego Dam. (See Figure 3-6).
ABSA 8	Kalamazoo River from Otsego Dam to Trowbridge Dam. Aquatic biota were collected upstream of Trowbridge Dam. Includes TBSAs 3 and 5. (See Figures 3-6).
ABSA 9	Kalamazoo River from Trowbridge Dam to Lake Allegan Dam. Aquatic biota were collected from Lake Allegan. (See Figure 3-7).
ABSA 10	Kalamazoo River from Lake Allegan Dam to Ottawa Marsh. Aquatic biota were collected downstream of Allegan Dam. Includes TBSA 1. (See Figure 3-8).
ABSA 11	Kalamazoo River from Ottawa Marsh to US 31. Aquatic biota were collected near Saugatuck. (See Figure 3-9).
ABSA 12	Portage Creek (See Figure 3-10).

Table 3-3
Assessment and Measurement Endpoints and ERA Null Hypotheses
API/PC/KR

Assessment Endpoint	ERA Null Hypotheses	Measurement Endpoints	Representative Receptor / Group
Preservation of the fish populations (e.g., smallmouth bass, white sucker, and carp) and communities utilizing the Kalamazoo River and Portage Creek system	<i>The levels of PCBs in water, sediment, and biota are not sufficient to adversely affect the structure or function of the fish populations in the Kalamazoo River and Portage Creek System.</i>	<i>Toxicity data</i> - Surface water and sediment total PCB concentrations affecting the survival, growth, or reproduction of fish	Carp Smallmouth bass Sucker
Preservation of the survival, growth, and reproductive capacity of aquatic receptors (e.g., benthic macroinvertebrates, fish, larval amphibians) utilizing the Kalamazoo River and Portage Creek system	<i>The levels of PCBs in water, sediment, and biota are not sufficient to adversely affect the survival, growth, or reproduction of plant and animal aquatic receptors utilizing the Kalamazoo River and Portage Creek system.</i>	<i>Toxicity data</i> - Surface water and sediment total PCB concentrations affecting the survival, growth, or reproduction of aquatic plants, fish, aquatic invertebrates, or larval amphibians	Aquatic plants Benthic invertebrates Fish Larval amphibians
Preservation of the survival, growth, and reproductive capacity of mammalian receptors (e.g., mouse, mink, muskrat, red fox) utilizing the Kalamazoo River and Portage Creek system	<i>The levels of PCBs in water, sediment, soil, and biota are not sufficient to adversely affect the survival, growth, or reproduction of mammalian receptors utilizing the Kalamazoo River and Portage Creek system.</i>	<i>Toxicity data and biota PCB concentrations</i> - Sediment, surface soil, and dietary item total PCB concentrations affecting the survival, growth, or reproduction of omnivorous and carnivorous mammals	Earthworm (dietary item) White-footed / deer mouse Muskrat Mink Red fox
Preservation of the survival, growth, and reproductive capacity of avian receptors (e.g., bald eagle and great-horned owl) utilizing the Kalamazoo River and Portage Creek system	<i>The levels of PCBs in water, sediment, and biota are not sufficient to adversely affect the survival, growth, or reproduction of avian receptors utilizing the Kalamazoo River and Portage Creek system.</i>	<i>Toxicity data and biota PCB concentrations</i> - Sediment, surface soil, and dietary item total PCB concentrations affecting the survival, growth, or reproduction of omnivorous and carnivorous birds	American robin Great horned owl Bald eagle